

1   **WHAT IS CLAIMED IS:**

2       1.     A compact fuel processor for converting a hydrocarbon fuel feed into  
3     hydrogen rich gas, comprising a processor assembly containing multiple concentric  
4     vessels for converting the hydrocarbon fuel feed into the hydrogen rich gas, wherein the  
5     hydrogen rich gas is suitable for direct feed to a fuel cell.

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7       2.     The compact fuel processor of claim 1, wherein the processor assembly  
8     comprises:

9             an oxidation core vessel containing an oxidation catalyst;

10            a reforming vessel surrounding the oxidation core vessel and forming a first  
11     annular space filled with autothermal reforming catalyst;

12            a desulfurizing vessel surrounding the reforming vessel and forming a second  
13     annular space filled with desulfurization catalyst;

14            a shift vessel surrounding the desulfurizing vessel and forming a third annular  
15     space filled with water gas shift catalyst; and

16            a preferred oxidation vessel surrounding the shift vessel and forming a fourth  
17     annular space filled with preferred oxidation catalyst.

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19       3.     The compact fuel processor of claim 2, wherein the oxidation core vessel  
20     oxidizes fuel cell anode tail gas to produce a hot exhaust gas.

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22       4.     The compact fuel processor of claim 3, wherein the hot exhaust gas  
23     preheats the hydrocarbon fuel.

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25       5.     The compact fuel processor of claim 2, further comprising an electric  
26     heater for preheating the anode tail gas prior to introducing the anode tail gas to the  
27     oxidation core vessel.

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29       6.     The compact fuel processor of claim 2, further comprising a second  
30     desulfurizing vessel external to the processor assembly for desulfurizing the hydrocarbon  
31     fuel feed.

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2           7.     The compact fuel processor of claim 6, wherein the second desulfurizing  
3 vessel is a replaceable canister.

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5           8.     The compact fuel processor of claim 4, wherein the hydrocarbon fuel feed  
6 is sequentially introduced to the first annular space, then to the second annular space,  
7 then to the third annular space, and then to the fourth annular space to produce the  
8 hydrogen rich gas.

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10          9.     The compact fuel processor of claim 8, further comprising a plurality of  
11 cooling coils for removing the heat of reaction produced in the first annular space, the  
12 second annular space, the third annular space, and the fourth annular space.

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14          10.    The compact fuel processor of claim 9, wherein a circulating coolant flows  
15 through the cooling coils.

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17          11.    The compact fuel processor of claim 10, wherein the circulating coolant is  
18 selected from a group consisting of air, water, and the hydrocarbon fuel feed.

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20          12.    The compact fuel processor of claim 2, wherein the each annular space is  
21 surrounded by heat resisting refractory.

22  
23          ~~13.~~   A compact fuel processor for converting a hydrocarbon fuel feed into  
24 hydrogen rich gas, comprising:

25               a reforming module for converting the hydrocarbon fuel feed into the hydrogen  
26 rich gas, wherein the hydrogen rich gas is suitable for direct feed to a fuel cell; and

27               an oxidizing module for oxidizing fuel cell anode tail gas to produce a hot exhaust  
28 gas, wherein the hot exhaust preheats the hydrocarbon fuel feed to the reforming module.

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30          14.    The compact fuel processor of claim 13, wherein the oxidizing module  
31 comprises:

1 a first heat exchanger core;  
2 an oxidation core vessel containing an oxidation catalyst; and  
3 a first desulfurizing vessel surrounding the oxidation core vessel and forming a  
4 first annular space filled with desulfurization catalyst; and  
5 wherein the oxidation core vessel oxidizes the fuel cell anode tail gas to produce a  
6 hot exhaust gas; and  
7 wherein the hydrocarbon fuel feed is preheated by the hot exhaust gas in the first  
8 heat exchanger coil to produce a preheated hydrocarbon fuel feed; and  
9 wherein the preheated hydrocarbon fuel feed is desulfurized in the first annular  
10 space to create a desulfurized hydrocarbon fuel feed.

11  
12 15. The compact fuel processor of claim 14, wherein the oxidation core vessel  
13 has a first set of external vertical fins for further preheating the preheated hydrocarbon  
14 fuel feed to produce a second preheated hydrocarbon fuel feed, and wherein the second  
15 preheated hydrocarbon fuel feed becomes the hydrocarbon fuel feed introduced to the  
16 first annular space.

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18 16. The compact fuel processor of claim 13, wherein the reforming module  
19 comprises:

20 a second heat exchanger coil;  
21 a reforming core vessel containing an autothermal reforming catalyst bed;  
22 a second desulfurizing vessel surrounding the reforming core vessel and forming  
23 a second annular space filled with desulfurization catalyst;  
24 a shift vessel surrounding the second desulfurizing vessel and forming a third  
25 annular space filled with water gas shift catalyst; and  
26 a preferred oxidation vessel surrounding the shift vessel and forming a fourth  
27 annular space filled with preferred oxidation catalyst; and  
28 wherein the hydrocarbon fuel feed is preheated by the hydrogen rich gas in the  
29 second heat exchanger coil to produce a third preheated hydrocarbon fuel feed; and

1 wherein the third preheated hydrocarbon fuel feed is sequentially introduced to  
2 the reforming core vessel, then to the second annular space, then to the third annular  
3 space, and then to the fourth annular space to produce the hydrogen rich gas.

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5 17. The compact fuel processor of claim 16, wherein the hydrocarbon fuel  
6 feed is a desulfurized hydrocarbon fuel feed.

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8 18. The compact fuel processor of claim 16, wherein the reforming core vessel  
9 has a second set of external vertical fins for further preheating the third preheated  
10 hydrocarbon fuel feed to produce a fourth preheated hydrocarbon fuel feed, and wherein  
11 the fourth preheated hydrocarbon fuel feed becomes the hydrocarbon fuel feed introduced  
12 to the reforming core vessel.

13  
14 19. The compact fuel processor of claim 16, wherein the third annular space  
15 has a third heat exchanger coil for reaction temperature control.

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17 20. The compact fuel processor of claim 16, further comprising an electrical  
18 heater for starting up the autothermal reforming catalyst bed.

19  
20 21. A compact fuel processor for converting a hydrocarbon fuel feed into  
21 hydrogen rich gas, comprising:

22 a heat exchanger coil;

23 a reforming core vessel containing an autothermal reforming catalyst bed;

24 a desulfurizing vessel surrounding the reforming core vessel and forming a first  
25 annular space filled with desulfurization catalyst;

26 a shift vessel surrounding the desulfurizing vessel and forming a second annular  
27 space filled with water gas shift catalyst; and

28 a preferred oxidation vessel surrounding the shift vessel and forming a third  
29 annular space filled with preferred oxidation catalyst; and

30 wherein the hydrocarbon fuel feed is preheated by the hydrogen rich gas in the  
31 heat exchanger coil to produce a preheated hydrocarbon fuel feed; and

1            wherein the preheated hydrocarbon fuel feed is sequentially introduced to the  
2    reforming core vessel, then to the second annular space, then to the third annular space,  
3    and then to the fourth annular space to produce the hydrogen rich gas.

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